Remote Automatic Material On-line Sensor

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Project Description

- *Low field magnetic resonance (optionally single sided) is used to perform continuous, remote measurements on industrial materials.*
  - Properties measured include hydrogen content, solid-to-liquid ratio and molecular mobility
  - System is designed to be compatible with industrial environments
  - System data output in formats compatible with process control equipment
  - System can be scaled up if larger sample dimensions are needed

Project Objectives/Goal

- **IOF need(s) addressed by this technology**
  - On-line measurement of material properties with accuracy comparable to off-line measurement.
- **Objectives**
  - Moisture content of wood/wood chips to ±0.5%
  - Moisture content of coal ±0.25%
- **Overall goal**
  - Provide rapidly updated material property measurements with required accuracy and affordable price

Technical Risks/Innovation

- **Technical risks**
  - Obtaining magnetic field quality with small rugged magnet
  - Receiver recovery time
  - High RF power
- **Innovation**
  - Rugged low cost magnet with good field homogeneity
  - RF coil uniquely suited for measuring wide lumber
  - Low cost MR electronic systems

Advancement of state-of-the-art; over competition

- Low system cost, good recovery times at low frequencies
- Can directly measure drying below fiber saturation point of wood

Task Performance

Past Technical Milestones

Milestone	Due Date	Completion Date	Comments
Interview IOF Industry staff to determine specifications	June 2000	August 2001	Complete for Forest Products
Initial lab tests of samples	Sept 2000	Dec 2000	Complete for Forest Products
Design magnet and RF subsystem	Dec 2000	June 2002	Delay waiting for specs/demands on personnel
Finalize design and obtain vendor quotes	Apr 2001	June 2002	

Progress Toward Performance Goals

- **Interviewing IOF industry personnel to determine needs**
  - ***Interviewed personnel at lumber companies, sawmills, engineered wood plants***
  - ***Very useful interview with Gene Wengert and Joe Denig on August 29-30, 2001 – set design specs for wood moisture measurement***
  - ***Numerous discussions with Don Nettles of Chevron Research***
  - ***Recent discussions with Clinton Lindbergh of Sabia***

Progress Toward Performance Goals

- **Design Magnet and RF subsystem**
  - ***Magnet designed to accommodate commercialization of LBNL work with wood chips***
  - ***Further design goal of measuring moisture content in center of wide lumber as well as edge – based on interview with Wengert and Denig***
  - ***RF probe design work for measuring center of wide lumber***
  - ***Considerable work at QM on high performance/low cost electronics (mainly for QR landmine detection)***
    - ***RF power amplifier cost at least an order of magnitude less than competing products, modular design allows for scaling up the system***
    - ***Improvements in low noise amplifiers allow for improved recovery time without loss in sensitivity***

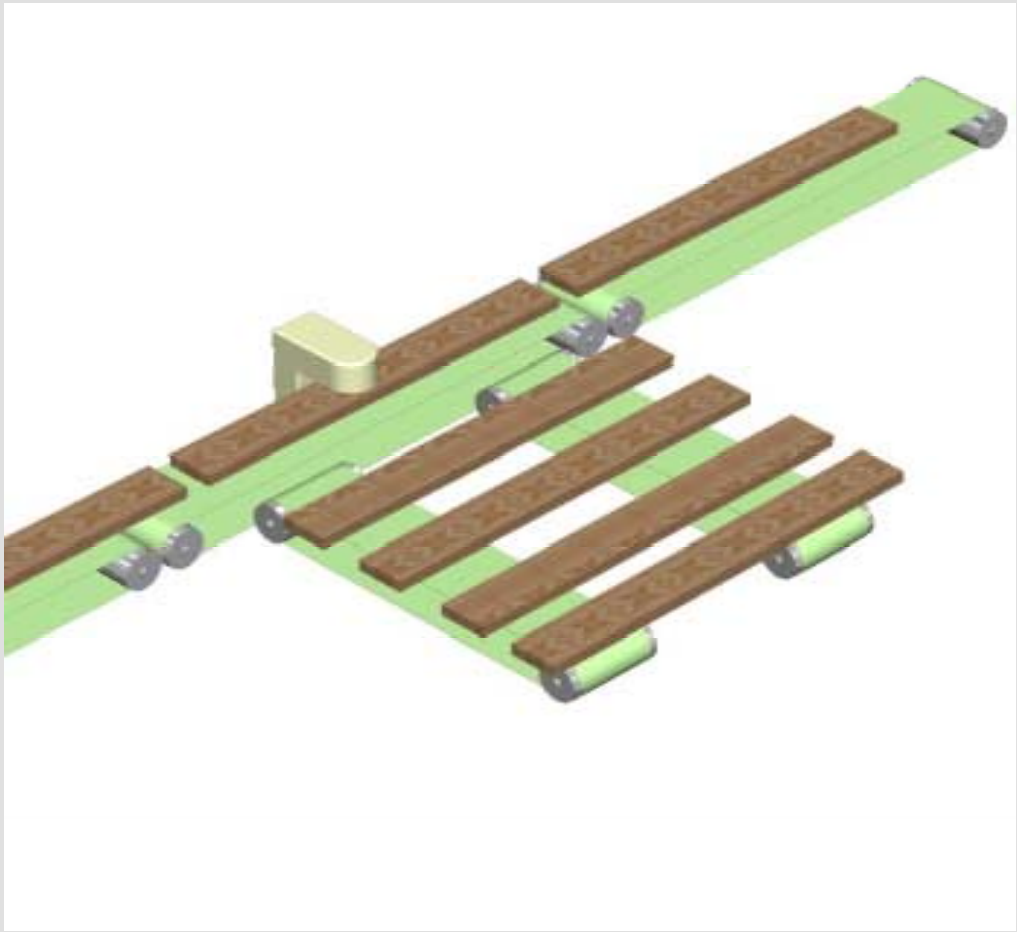
Progress Toward Performance Goals

- **Perform Measurements on samples**
  - Wood moisture content measurement accuracy is better than 1%
    - Accuracy same for solid wood and wood chips
  - Coal moisture content accuracy is disappointing
    - Measurements on Argonne Premium coal samples showed poor absolute accuracy, much better with relative bound versus free moisture content
    - Difficulty in getting well characterized coal moisture content (other than Argonne Premium coal amples)
      - One goal of collaboration with Sabia is obtaining well characterized coal samples

Progress Toward Performance Goals

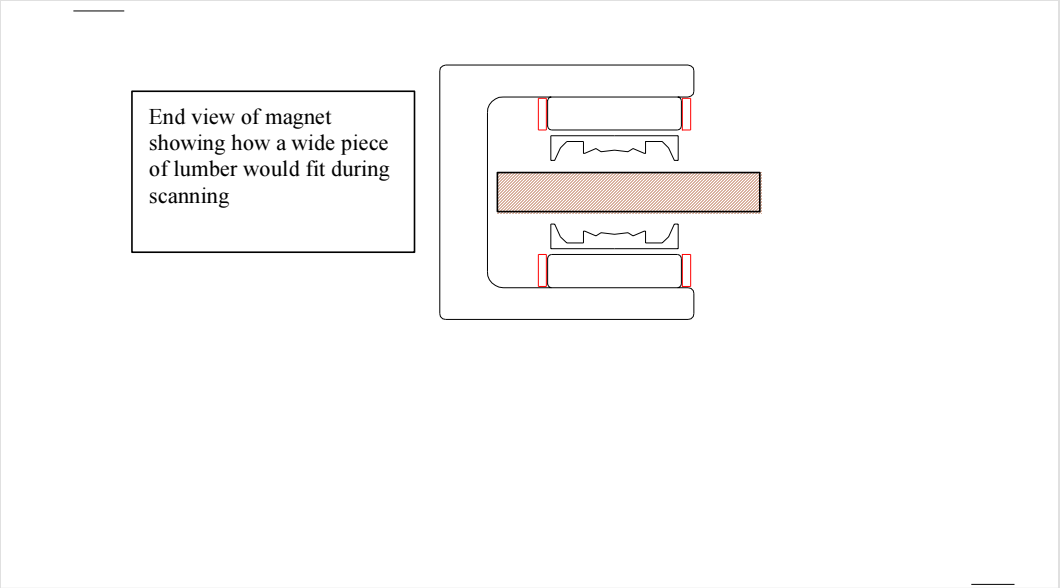
- **Finalize drawings and obtain vendor quotes**
  - ***Have quote for permanent magnet material from Ogallala***
  - ***Magnet drawings expected to be finished June 14***
  - ***RF coil drawings to be complete mid July***
  - ***QM electronics will depend on schedule for latest generation***
    - ***Will use next generation if available by July***
    - ***Other wise use current generation***

Lumber Moisture Content



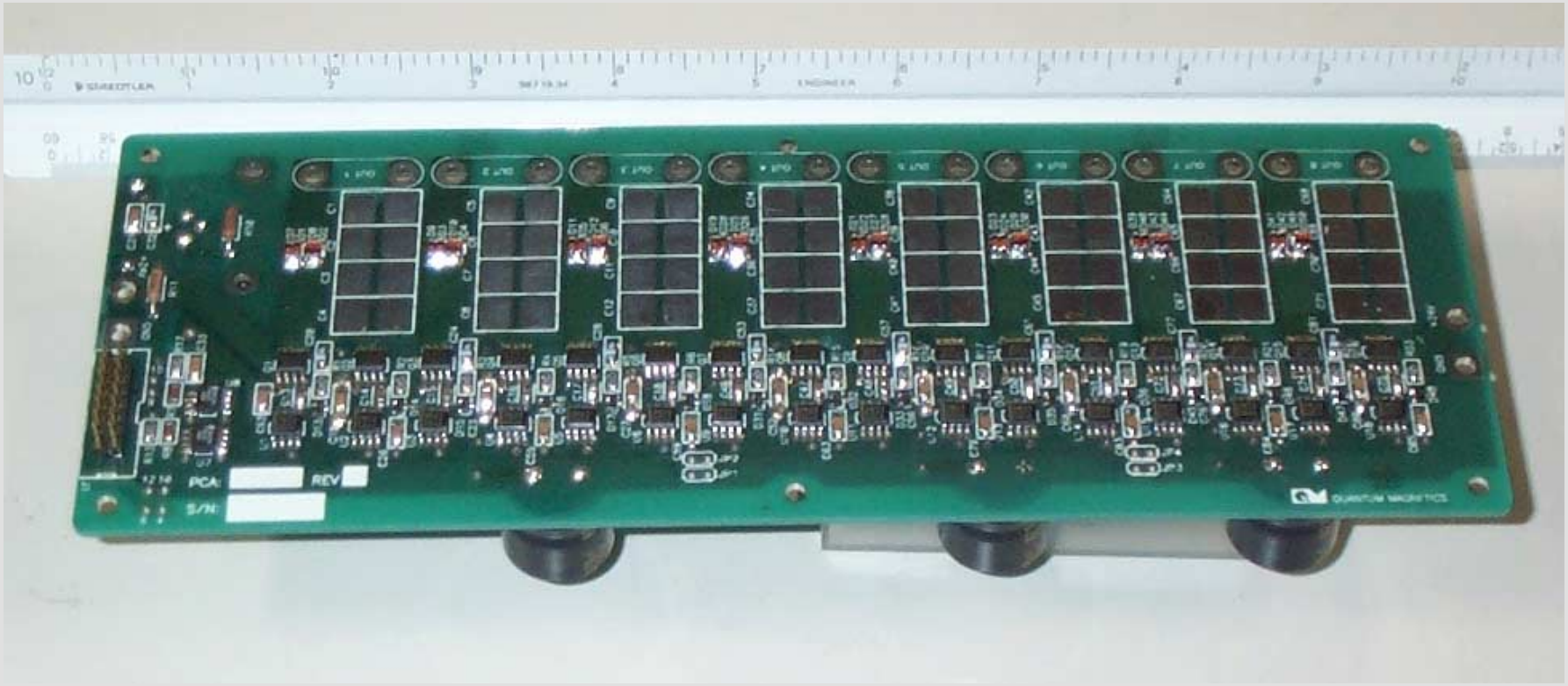
A proposed application of the system using the small C magnet.

Magnet cross section



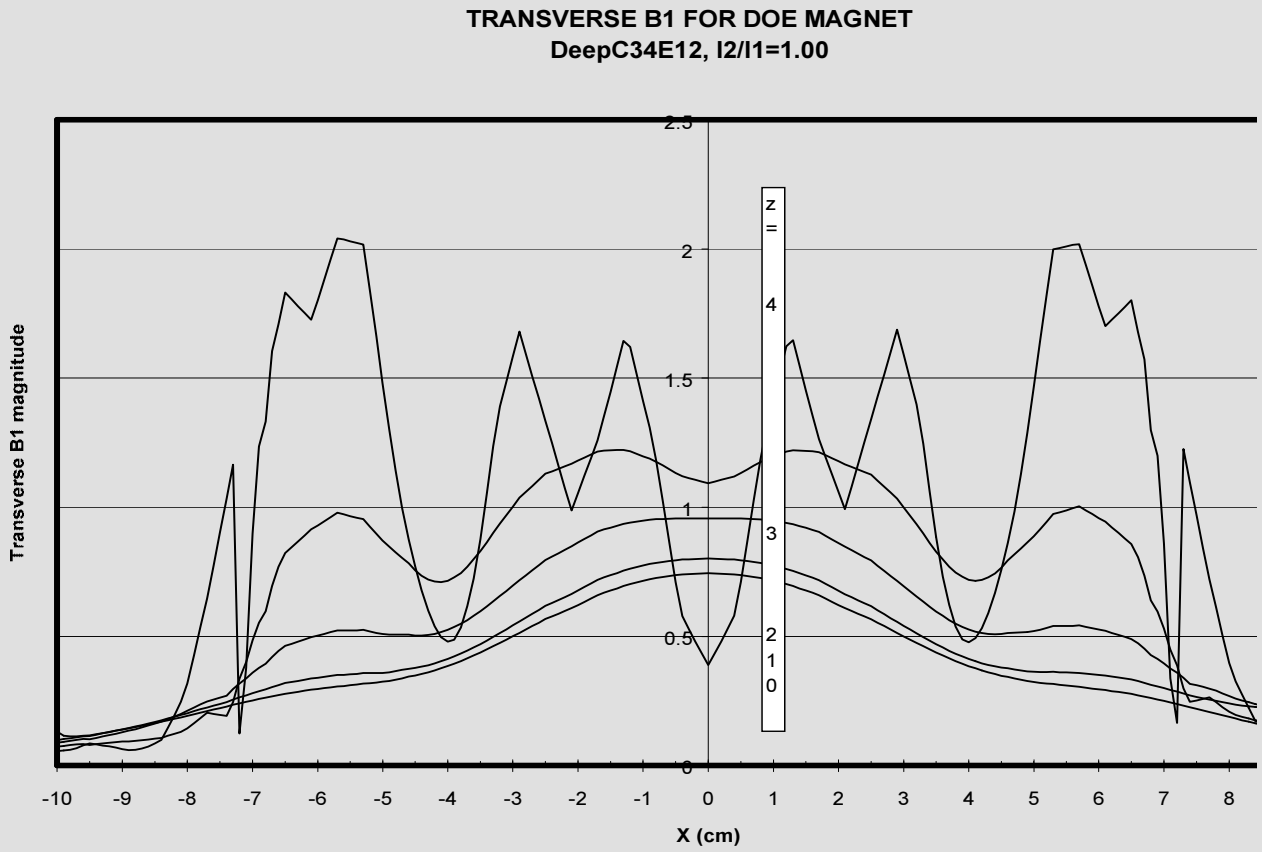
When equipped with the appropriate RF coil, the magnet is capable of handling lumber sizes up to 2 by 12 inches (5 by 30 cm). For use with liquid, powder or granular materials, a cylindrical sample space of up to 7.5 cm can be accommodated.

Low cost RF power amplifier



This is a 6 KW class D RF power amplifier. Advantages are small size, light weight, good efficiency and very low cost. Amplifiers can be run in parallel for increased power output.

B_1 Plot of E-quad coil model



Ideal plot would be no variation with respect to Z and flat over X=±4cm, with rapid fall-off outside of X=±4cm. Modeled data shows good spot measurement capability for lumber less than 4cm thick.

Commercialization

- **Proposed plant tests/deployments, and planned use in IOF manufacturing plant(s)**
  - Hardwood sawmill, most likely John Martin of Louisiana
    - January 2003
  - Sabia
    - Spring 2003 at Sabia

- **Commercialization path & partners**
  - Partnering with LBNL for commercialization of their work on moisture content measurments of wood chips
  - Manufacturing to be done by InVision Technologies

Performance Merits

- **Improving energy efficiency**
  - How will energy be saved?
    - Improved moisture content measurement allows for better control of kiln drying
    - Improved moisture content measurement of coal will allow for improved firing of steam boilers
  - What are the energy savings (per installed unit and nationwide)?
    - 300,000 KWH/yr for kiln drying oak
    - 75,000,000 KWH/yr for kiln drying oak

Performance Merits

- **Improving product quality**
  - How will product quality be improved?
    - Less cracking and checking of hardwood lumber due to improved kiln drying
    - Less lumber damaged due to overdrying
  - How will this improvement be quantified?
    - Noting changes in the average grade of lumber after drying

Performance Merits

- **Minimizing waste**
  - How will waste be minimized?
    - Less cracking and checking of hardwood lumber from improved kiln operation
  - How will waste minimization be quantified?
    - Losses during are relatively well characterized in the hardwood lumber industry (typically 8%)

Path Forward

Future Technical Milestones

Milestone	Due Date	Completion Date	Comments
Procure and Fabricate Components	June 2001	August 2002	
Assemble system	August 2001	Sept 2002	
In-Lab tests	Oct 2001	Oct 2002	Go/No-go
Application Engineering	Dec 2001	Dec 2002	
Beta Testing	June 2002	June 2003	

Path Forward

- **Next steps**
  - Order and fabricate magnet components
  - Assemble, test and adjust magnet
  - Assemble and test balance of system
  - Lab test system on wood and coal samples
  - Field test system

- **Go/no-go consideration(s)**
  - Maintain interest from at least two IOF's
  - Interest from potential customers